LIGHTING DATA

EDISON LAMP WORKS
OF GENERAL ELECTRIC COMPANY

GENERAL SALES OFFICE HARRISON, N. J.

Lighting of Schools

Data compiled by
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Lighting Service Department

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Synopsis: Page

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Introductory

Artificial lighting should be provided for all schools. Although the majority of schools are not used at night, it is essential that artificial light be available for supplementing daylight on dark days. The method of securing this additional light should be given careful consideration. There are too many instances where the lighting units are apparently located without any thought as to the ultimate result. Clear, bare incandescent lamps are often used and, even if a reflector is supplied, the unit is hung in such a position as to result in eyestrain.

FIG. 1

Night View of a Primary Classroom with Direct Lighting. Six 100-watt MAZDA C Lamps are employed in etched prismatic deep bowl reflectors. The room is 24 by 30 ft., the power consumption 0.8 watts per square foot, and the intensity of illumination over 4 foot-candles. The system is efficient; the light evenly distributed, although some of the other systems give a more pleasing appearance and better diffusion

It is extremely important to protect the eyesight of the growing child, for injury to this can never be thoroughly repaired. Everyone will agree that proper lighting is an essential aid to clear, comfortable vision.

Before entering into a description of actual installations, it is well to sum up a few of the desirable qualities of illumination and then show, by practical illustrations, accompanied by data, the methods of designing systems which do not violate the essentials of good lighting.

Intensity

It is self-evident that the proper amount of light must be supplied for any kind of work. The correct intensity is necessary in order that everything which is to be seen may be seen clearly and without fatigue. No matter what system is used, unless enough light actually reaches the desks, then the lighting system is inad-

FIG. 2

Opalescent Semi-enclosing Fixtures with 100-watt MAZDA C Lamps are used in this Class-room. The glassware is sufficiently dense to thoroughly diffuse the light. The four-outlet arrangement is followed. The double window shades, permitting effective control of natural light, are worthy of note

quate. The fault usually lies in too low an intensity rather than too high. We sometimes hear complaints that places are overlighted, but it is usually apparent to one familiar with the principles of lighting that it is not a question of excess amount of light on the

work, but rather a lack of diffusion or one of the other features of good lighting. In artificial lighting the values are very much lower than we ordinarily find in daylight, but our eyes can adjust themselves to a wide range of intensities.

It is not necessary to go into technical detail when we say that the unit of illumination intensity is the foot-candle (defined as the intensity to which a surface normal to a 1-candle-power source, at a distance of 1 foot, is illuminated). In an installation we measure this with a portable photometer. The range of desirable intensities for classrooms is given in the table below:

Classroom	3-5 foot-candles on desks
Study Room	4-8 foot-candles on desks
Office	4-6 foot-candles on desks
Cloak room	0.8-1 foot-candles on floor
Corridor	0.8-1 foot-candles on floor
Laboratory	3-6 foor-candles on tables

FIG. 3

A Laboratory Lighted by Two 100-watt Mazda C Lamps in a Simple Type of Semi-direct Unit. An Intensity of 3 foot-candles is secured by this means. The absence of glaring reflection from the blackboards is noteworthy

Of course, it is not necessary to adhere absolutely to these values, but it is undesirable to drop below them. An average of 3 foot-candles illumination will be quite satisfactory for most purposes in the classroom, yet when fine detail is to be observed, it is often desirable to go considerably higher.

A distinction must be drawn between those classrooms which are used for clerical work, reading, writing, etc., and those used for sewing, art, metal work, drafting, chemical experiments and the like. The latter rooms should be illuminated to the higher values given in the tables. Even though we can supply adequate light for any process, it is inadvisable to allow the young child to do fine needle work under artificial illumination. The periods can be so planned that this could be carried on by daylight.

Diffusion

The harmful effects of glare cannot be over emphasized. The likelihood of glare from light sources is becoming greater and greater with the development of higher efficiency lamps with their increased intrinsic brightnesses. Practically, all commercial light sources are far too brilliant to be in the field of view without producing a blinding effect and reducing the ability to see. When bright light sources are placed high above the head the eyebrows protect the eyes, as will be noted out of doors under the noonday sun, but from the construction of our buildings, illuminants must be hung rather low and come within the field of view. We therefore always reduce the brilliancy of the light by means of diffusing globes, shades or reflectors which either enlarge the light source or actually hide it from view.

Diffusion also softens the shadows so that glaring contrasts are less likely. It is not desirable, however, to go to such an extreme diffusion that we entirely eliminate shadows, for they are very essential to show the contour or shape of objects. Over-diffusion or flat illumination is trying to the eyes and unpleasant.

Not only must we take care of the light sources themselves in providing diffusion, but the walls and other objects must be given attention. Dull rather than polished surfaces are desirable here, and even a depolished or waxed finish is more desirable than varnished or highly polished surfaces on the desk and other furniture, as the latter produce mirrorlike effects in reflecting the light sources.

When we think of diffusion, its antithesis, glare, also comes to mind and, as pointed out, intrinsic brightness is one of the greatest sources of glare, but it is not the only cause. A large area of low intensity may be very annoying. Everyone has experienced the glare from a cloudy sky. Excessively bright contrasts may produce glare. This can be illustrated as follows: A lighted incandescent

lamp in a dark room is most annoying, whereas the same lamp viewed in an open window against the sky is not at all noticeable. This has a practical bearing in the schoolroom where blackboards are adjacent to white walls of a high brightness.

Direction of Light

It is natural to direct the light on the object to be seen and not in the eye; therefore, since it is necessary to hang lamps high and out of the line of vision, we equip them with reflectors or other devices to direct the light downward on the working plane. It is

FIG. 4

Totally Indirect Illumination Applied to a Study Room. The excellent diffusion provides conditions for comfortable vision. Annoying reflections from the surface of calendered paper are eliminated. Light colored ceiling and walls are necessary for such lighting systems

always desirable to shield or diffuse the light at angles near the horizontal. In most interiors we space outlets symmetrically throughout the room, but with the schoolroom, as with the machine shop, the shadow effect is very important, so we have the maximum

light coming slightly forward and from the left to diminish the head and hand shadows; as far as possible the direction of daylight is imitated, sometimes much improved.

Distribution of Light

Under this heading we have two extremes; one known as local lighting and the other as general illumination. In local lighting we provide relatively low candle-power light sources, located rather close to the work, furnishing a high intensity of illumination over a small area.

There is a tendency to use local lighting in drafting rooms, machine shops and sewing rooms. This lamp is often under the control of the pupil. He knows very little about the proper use of lamps and often works in his shadow. Good general lighting would, therefore, be much better. Local lights very often cause annoying glare to pupils at adjacent tables. The system is always unsightly, the drop cords are often tied back, strictly against the rules for good wiring and a dangerous practice.

In general illumination much larger lamps are used, hung as high as possible, providing almost uniform lighting throughout the room; in fact, there is a much less variation in intensity across a room than is possible with natural lighting from windows as ordinarily placed. It simulates daylight, makes the room appear much brighter than local lighting; is, in general, independent of the arrangement of furniture and, without question, is the system best suited for schoolroom lighting. The wiring cost is much lower, there is less likelihood of glare, and no danger of breakage of lamps or reflectors.

The color of walls and ceilings has a very direct influence on the distribution and actual quantity of light delivered on the desks and the reader is urged to study Bulletin Index 15, which deals with this phase of lighting.

General Consideration

Whatever light source is provided it should be steady. Everyone has experienced annoyance with fluttering or flickering light. This fluctuation interferes with the ability to see and may cause pain by the straining of the muscles of accommodation of the eye.

Whatever light is used should be reliable to insure continuity in service. This is particularly important in the auditorium or other gathering place where, in the event of failure of light sources, panic might ensue.

The most efficient lamp of the type chosen should be employed for reasons of economy, for with it the desirable intensity of light can be obtained at a minimum cost. The maintenance cost should be low, but we must never let the factor of economy overbalance features such as diffusion, set forth above. The cost of light is such a small item that the best system possible is well warranted, even though it is somewhat less efficient in light utilization than some other means of lighting less suited.

The MAZDA lamp, meeting in a most complete manner the features outlined above, has come to be practically the standard illuminant for this class of service. For further information on the lamps themselves see Bulletin Index 1.

The proper maintenance of a lighting system is of such importance that it has been deemed advisable to treat this subject in considerable detail in Bulletin Index 14.

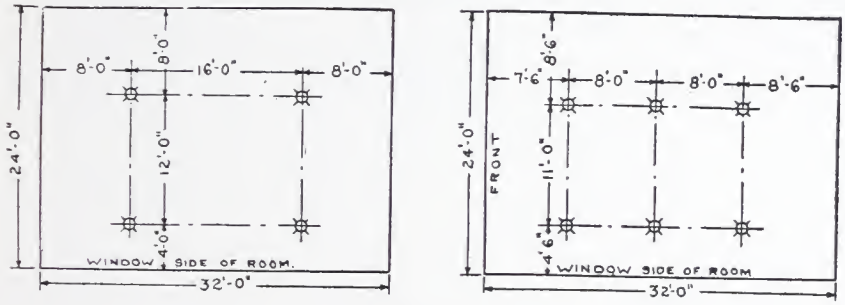

FIG. 5

(a) Semi-indirect Lighting Scheme for Typical Schoolroom—four 200-watt Clear Mazda C Lamps in dense glass semi-indirect units. (b) Direct Lighting Scheme for Typical Schoolroom—six, 100-watt Bowl Frosted MAZDA C Lamps in etched prismatic or dense opal deep bowl reflectors

The wiring should be so arranged that the switches are readily accessible. It is often desirable to subdivide the circuits as follows: Have one circuit which controls the lamps near the teacher's desk so that he or she can work after hours without all of the room lighted; the main lights arranged on two circuits on a 2-point switch, the first turn of which lights the units away from the windows, the second turn putting all the lights on. Thus part of the room at a time can be illuminated as daylight gradually diminishes; a very economical arrangement.

Comparison of Various Lighting Systems

Obviously, direct lighting with efficient reflectors is the most economical of the three methods, for the effect of wall and ceiling

reflection is minimized. Direct lighting, however, may be so arranged to produce glare either from the light sources themselves or by reflections from the objects lighted. Some arrangements of direct lighting may not evenly distribute the light, and as a result, produce dense shadows. It is generally not so decorative as the other methods. Direct lighting should employ translucent glassware; opaque reflectors should not be used in schoolrooms as the ceiling would be in darkness, which is an undesirable condition.

Dense opal and etched prismatic deep bowl reflectors are the most efficient for direct lighting. They transmit but a small proportion of the light and their surface brightness is therefore of a low order. The light density deep bowl reflectors are satisfactory but not so efficient, transmitting more light, and are brighter. The flat type reflector should never be used in the schoolroom, for it is almost impossible to conceal the filament from view when using this style of shade.

More outlets are required for direct lighting than for the indirect systems, in order that multidirectional light may be provided, and smaller size units must be used to keep down the intrinsic brightness of the reflector.

Semi-indirect lighting is not glaring if dense glass be employed in the dishes; it can be made very decorative; the light is usually evenly distributed and such shadows as are produced are very soft and do not cause inconvenience. From these factors one can readily conclude that the eye will work at a better efficiency than under direct lighting. Of course, for the same illumination somewhat more power must be used.

Semi-indirect units, to produce the best effect, should be of rather dense glass. If light density glass is used, unless the bowl is very large, it becomes very bright and the system loses many of its advantages, dropping back to the direct lighting class where a number of fairly bright objects are in the field of vision.

The decorations of the glassware, if any, should be very simple, for any appearance of excessive ornateness would be out of keeping with the character of the schoolroom. Deep crevices in the glass, although they may be decorative, are objectionable from the standpoint of dust accumulation.

Semi-indirect lighting has an advantage over totally indirect in that the place where the light originates in readily discernible. This has a psychological effect on the individual and makes people feel more at ease.

Totally indirect lighting is least likely to produce glare, the light is very evenly distributed and comfortable to work under. The objection has been raised that there is a total absence of shadow making the room appear flat. With a properly designed system, however, this is not true, but shadows are, of course, minimized.

There are two general forms of totally indirect units; one employs mirrored reflectors in decorative housings, and the other porcelain enameled reflectors with different styles of casings. The mirrored glass is more efficient although somewhat higher in first cost.

FIG. 6

A Typical Basement Lunchroom Illuminated to a Moderate Intensity with 60-watt Edison MAZDA Lamps in Simple Hemispherical Semi-indirect Fixtures

From the very nature of things this is the least efficient of the three methods, but a number of investigators have proved to their own satisfaction, at least, that the eye operates best, with minimum fatigue, under totally indirect lighting. Of course such tests are conducted under one particular set of conditions; other tests under different circumstances might produce a divergence of results. While laboratory tests are very useful, yet practice in general is a better indication of the real suitability of a system. The great number of very satisfactory semi-indirect systems being installed

causes one to believe that for the most conditions proper semi-indirect lighting is best suited.

The fixture in the ordinary classroom serves a purely utilitarian purpose—that of supporting the glassware and lamp. It should therefore be simple in character. The means of suspension of any type of lighting unit should be such that there is absolutely no danger of the glassware falling, and especially in the case of indirect units it is desirable to have some convenient means of cleaning.

It is always desirable to hang units as high as possible to keep them out of the range of vision. This is just as efficient from a light utilization standpoint, for as we hang a lamp higher we choose a reflector which concentrates the light in a narrower angle. No lamps should come within the solid angle subtended at the eye between blackboard and a space two feet above it.

Blackboards

There is a likelihood of glaring reflections from blackboards and they should, therefore, always have matt rather than polished surfaces. It is sometimes possible to get rid of this reflection by tilting the boards slightly. Blackboards which will be written on with colored chalks, and those that are more than twenty feet away from the pupil, should be especially lighted to an intensity approximately 60 per cent higher than the intensity in the rest of the room. This can be accomplished by the use of properly screened and judiciously placed local units. For clear vision, blackboards should not be located between windows.

Typical Arrangements

In Fig. 5 are shown two schemes of lighting which are satisfactory for the average size schoolroom (24 by 32 feet), and the size of lamp specified represents good average practice fulfilling the requirements set forth above.

To predetermine the results obtained from a given lighting system is a comparatively simple matter and several methods are outlined in Bulletin Index 13, entitled, "The Calculation of the Lighting Installation."

Lunch, Wash, Locker, Cloak Rooms and Corridors

The lighting of these portions of the building is purely utilitarian. The decorative element does not enter; the desirable intensity of light should be supplied in the most efficient manner. Direct

lighting with prismatic or dense opal bowl reflectors, with outlets spaced symmeterically throughout the room, is suitable, allowing from ¼ to ½ watt to each square foot of floor area. The primary function of corridor illumination is to provide enough intensity for anyone to pass along without danger of stumbling or interfering with another person. This, of course, can be accomplished with low candle-power lamps spaced rather widely and equipped with diffusing glassware or reflectors giving a wide spread of the light as uniform illumination is not necessarily essential. A row of outlets symmetrically spaced along the center line of the ceiling

FIG. 7

A Dissecting Room Provided with the High Intensity of Illumination Necessary for Efficient Work. Observation of detail is much simplified under such lighting. Daylight MAZDA lamps materially assist in color discrimination. 500-watt bowl frosted lamps are used in deep bowl enameled steel reflectors. Outlets are spaced 15 by 12 ft. Lamps are 10 ft. above the floor, giving an average intensity of illumination over 10 foot-candles

is generally to be preferred and any of the three systems (direct, semi-indirect or totally indirect) will prove satisfactory. Sometimes the building is so laid out as to make ceiling outlets inadvisable. In this case bracket or wall fixtures must be employed. In general, 60-watt lamps on 15-foot centers are adequate. If the corridor is wide, however, the next larger size lamp is better fitted.

Miscellaneous Rooms

Proper illumination of the gymnasium and exercising rooms is, of course, very important and the reader is referred to Bulletin Index 44, "The Lighting of Armories and Gymnasiums."

The machine and pattern shops have especial demand for artificial illumination which are quite different from those of the other parts of the buildings. A study of Bulletins Index 62 and 63, which treat Machine Shops and Woodworking Plants, will indicate the type and arrangement of equipment best suited.

The laboratory requires a relative high intensity of illumination

FIG. 8

A Kindergarten Room Illuminated by the Totally Indirect Method. The eyesight of the young child should be carefully protected and would be with such lighting

in order that the progress of experiments may be carefully watched. The general layout suggested for the classroom is satisfactory for the laboratory. In the chemical department, however, acid fumes will attack metal parts of ordinary fixtures and soon make them useless. For this reason porcelain enameled reflectors and porcelain receptacles or sockets are well adapted. The RLM standard dome reflector with bowl enameled MAZDA C lamp makes an excellent lighting device for such rooms. It is efficient, durable, inexpensive and diffuses the light satisfactorily.

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The Foot-candle Meter

A small portable photometer, known as the "Foot-candle Meter," has recently been developed and is sold for the low price of $25.00. This instrument enables one to read, at a glance, the illumination on the desk, workbench or table. It is most simple in operation and very compact. The Foot-candle Meter will prove very valuable to Boards of Education, architects, designing engineers and others having charge of school lighting. With its aid they are enabled to check up existing installations and determine whether the intensities conform to modern standards which insure protection of the eyesight. In planning new buildings much interesting information, on both natural and artificial illumination conditions, can be obtained if the device is used. No school system can afford to be without one if those in authority are giving due consideration to the question of providing proper lighting.

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